INSTITUTE ELECTIVES (EEE)

INSTITUTE ELECTIVE I

Slot	Category Code	Course Code	Courses	L-T-P-J	Hours	Credit
E	IEC	23IEL31M	Introduction to Flight Dynamics and Control	3-0-0-0	3	3
		23IEL31N	Introduction to Power Processing	3-0-0-0	3	3
		23IEL31O	Electrical Drives and Control for Automation	3-0-0-0	3	3
		23IEL31P	Artificial Intelligence in Power Systems	3-0-0-0	3	3

INSTITUTE ELECTIVE II

Slot	Category Code	Course Code	Courses	L-T-P-J	Hours	Credit
E	IEC	23IEL42M	Architectural Lighting Design and Control	2-1-0-0	3	3
		23IEL42N	Electric Vehicles	3-0-0-0	3	3
		23IEL42O	Process Control and Automation	3-0-0-0	3	3
		23IEL42P	Sustainable Energy Management	3-0-0-0	3	3

INSTITUTE ELECTIVE 1

Course Code	Course Name	Category	L-T-P-J	Credit	Year of Introduction
23IEL31M	INTRODUCTION TO FLIGHT DYNAMICS AND CONTROL	IEC	3-0-0-0	3	2023

i) **COURSE OVERVIEW**: This course provides a fundamental understanding of control systems, aerodynamics, aircraft stability, and flight dynamics, catering to students from various engineering disciplines. It covers key concepts such as airfoil characteristics, aircraft motion, flight control systems, and emerging technologies like UAV control and AI-driven flight automation, equipping students with the foundational knowledge required for aerospace applications.

ii) **COURSE OUTCOMES**

After the completion of the course, the student will be able to:

CO1	Explain fundamental concepts of control systems, stability, and state-space representation.	Understand
CO2	Utilize aerodynamic concepts to analyse airfoil characteristics, calculate aerodynamic forces, and assess aircraft performance parameters such as lift, drag, and stalling behaviour.	Apply
CO3	Make use of root locus and Routh-Hurwitz criteria to assess the stability of control systems and understand the impact of control surfaces on aircraft stability.	Apply
CO4	Explain aircraft dynamics, flight control systems, and stability augmentation techniques.	Understand
CO5	Explain modern flight control technologies, UAV applications, and future trends in aerospace automation.	Understand

iii) **SYLLABUS**

Introduction to flight dynamics, open-loop and closed-loop control, transfer function, time-domain analysis, state-space representation, controllability, and observability.

Standard atmosphere, aerodynamic flows, Mach and Reynolds numbers, airfoil characteristics, lift and drag, stalling, drag polar, flight equations, thrust and power requirements, range, and endurance.

Stability concepts, Routh-Hurwitz criterion, root locus, aircraft control surfaces (elevator, aileron, rudder, flaps, spoilers), wind tunnels, and flow similarity.

ircraft motion modes (short period, phugoid, spiral divergence, Dutch roll), static and dynamic stability, lateral and longitudinal dynamics, autopilot systems, and stability augmentation.

Fly-by-wire systems, UAV control challenges, AI and adaptive control in aerospace, flight simulation tools, and future trends in aerospace automation.

iv) a) **TEXT BOOKS**

1. John D. Anderson Jr., *Introduction to Flight*, McGraw-Hill, 2021.
2. Etkin B. & Reid L.D., *Dynamics of Flight: Stability and Control*, Wiley, 1996.
3. Nelson R.C., *Flight Stability and Automatic Control*, McGraw-Hill, 1998.
4. Cook M.V., *Flight Dynamics Principles*, Butterworth-Heinemann, 2012.

5. Stevens B.L. & Lewis F.L., *Aircraft Control and Simulation*, Wiley, 2015.

b) REFERENCES

1. Anderson J.D. Jr. *Fundamentals of Aerodynamics*, McGraw-Hill, 2016.
2. Houghton E.L., & Carpenter P.W. *Aerodynamics for Engineering Students*, Elsevier, 2017.
3. Abbott, I.H. & von Doenhoff A.E. *Theory of Wing Sections*, Dover Publications, 1959.
4. McCormick B.W., *Aerodynamics, Aeronautics, and Flight Mechanics*, Wiley, 1994.
5. McLean D. *Automatic Flight Control*, Prentice Hall, 1990.
6. Roskam J. *Airplane Flight Dynamics and Automatic Flight Controls*, DAR corporation, 2001.
7. Austin R. *Unmanned Aircraft Systems: UAV Design, Development and Deployment*, Wiley, 2011.
8. Dorf R.C. & Bishop R.H., *Modern Control Systems*, Pearson, 2021.
9. Ogata K., *Modern Control Engineering*, Pearson, 2010.
10. Kuo B.C., *Automatic Control Systems*, Pearson, 2018.
11. Nise N.S., *Control Systems Engineering*, Wiley, 2021.
12. D'Azzo J.J., *Linear Control System Analysis and Design*, McGraw-Hill, 2011.

v) COURSE PLAN

Module	Contents	No. of hours
I	**Fundamentals of Control Systems and Stability** **Introduction to control system**: Open loop and closed loop control systems - Transfer function of LTI systems – characteristic equation – Type and order of system. Time domain analysis of control systems: Standard test signals – Transient and steady state responses – first and second order systems – time domain specifications – step responses of first and second order systems. **Introduction to state space**: state equation of linear continuous time systems – Eigen values and Eigen vectors of system matrix – concept of controllability & observability – relationship between state equations and transfer function.	**8**
II	**Aerodynamics and Aircraft Performance** **Introduction to Aerodynamics:** standard atmosphere – definition of altitudes–density, pressure and temperature altitudes. Aerodynamic flows – inviscid and viscous flows – incompressible and compressible flows – Mach number – laminar and turbulent flows – Reynolds number. **Airfoils**: Airfoil nomenclature – symmetric and cambered airfoils – generation of lift. Wing geometry –aspect ratio – chord line – angle of attack. **Aerodynamic forces and moments**: aerodynamic coefficients – lift, drag and moment coefficients – lift curve, drag curve – stalling of airfoil.	**10**

	Aircraft Performance: Drag Polar – Equation of motion of aircraft for level, un–accelerated flight. Thrust and power required for level, un–accelerated flight– thrust and power available – condition for maximum velocity.	
III	**Aircraft Stability and Control Surfaces** **Concept of stability:** Bounded Input Bounded Output stability – stability of feedback system – location of poles and stability – Routh Hurwitz stability criterion. **Root locus:** General rules for constructing Root loci – stability from root loci – effect of addition of poles and zeros. **Control surfaces**: elevator – aileron – rudder – dihedral angle and its effects – flaps and slots – spoilers. Flow similarity – Wind tunnels – open and close wind tunnels.	**9**
IV	**Aircraft Dynamics and Flight Control** **Aircraft dynamic modes**: Short period, phugoid, spiral divergence, and Dutch roll (concepts only, minimal mathematics). **Aircraft Stability and Control**: Static and dynamic stability – conditions for longitudinal static stability. Longitudinal and lateral dynamics (linear state space model) – Longitudinal dynamic modes - short period, phugoid. Lateral and directional dynamic stability – Spiral divergence and dutch roll (concepts only - mathematical derivations not needed) **Autopilot and flight control systems**: Actuators, displacement autopilots, pitch displacement, attitude hold, velocity hold. Block diagrams and control design for aircraft stability augmentation systems.	**9**
V	**Emerging Trends in Flight Control and UAV Applications** Introduction to fly-by-wire control systems: Digital flight control and electronic stability. Unmanned Aerial Vehicles (UAVs): Flight control challenges, stability considerations, autonomous navigation. Introduction to Adaptive and Intelligent Control: AI and machine learning applications in aerospace control. Flight Simulation and Software Tools: Introduction to computational tools for flight dynamics analysis. Future Trends in Aerospace Control: Hypersonic flight, space vehicle control, and automation in modern aircraft.	**9**
	Total hours	**45**

vi) ASSESSMENT PATTERN

Continuous Assessment : End Semester Examination – 40 : 60

Continuous Assessment		
Attendance	:	5 marks
Assignments	:	15 marks
Assessment through Tests	:	20 marks
Total Continuous Assessment	:	**40 marks**
End Semester Examination	:	**60 marks**
TOTAL	:	**100 marks**

vii) CONTINUOUS ASSESSMENT TEST

- No. of tests : 02
- Maximum Marks : 30
- Test Duration : 1 ½ hours
- Topics : 2 ½ modules

viii) END SEMESTER EXAMINATION

- Maximum Marks : 60
- Exam Duration : 3 hours

Course Code	Course Name	Category	L-T-P-J	Credit	Year of Introduction
23IEL31N	INTRODUCTION TO POWER PROCESSING	IEC	3-0-0-0	3	2023

i) COURSE OVERVIEW

This course introduces power electronics and its applications in power conversion, electric drives, renewable energy, and electric vehicles. It covers power semiconductor devices, AC-DC, DC-DC, and DC-AC converters, motor control, solar and wind energy systems, power supplies, and EV powertrains and charging technologies. Students will gain fundamental knowledge of power processing systems used in industrial, renewable energy, and transportation sectors.

ii) COURSE OUTCOMES

After the completion of the course, the student will be able to:

CO1	Explain the power semiconductor devices and wide bandgap devices.	Understand
CO2	Explain the operation of AC-DC rectifiers, DC-DC converters, DC-AC inverters, AC voltage controllers, and the impact of Total Harmonic Distortion.	Understand
CO3	Utilize power electronic converters to control electric motor drives and implement applications in industrial systems like heating, lighting, robotics, and automation.	Apply
CO4	Illustrate the power electronics applications in renewable energy systems, including solar PV, wind energy, energy storage, grid integration, microgrids, and smart grids.	Understand
CO5	Explain power supplies and power electronics in electric vehicles, powertrain, charging technologies and energy storage solutions.	Understand

iii) SYLLABUS

Power semiconductor devices – Diode, SCR, MOSFET, IGBT – operation and characteristics, wide bandgap devices (SiC, GaN), applications in renewable energy and transportation.

Single-phase fully controlled rectifier (R, RL load), DC-DC converters – Buck, Boost, Buck-Boost, single-phase full bridge inverter – square-wave operation, sinusoidal PWM, THD, introduction to AC voltage controllers.

Electric drives – block diagram, 4-quadrant DC motor, v/f control of induction motor, industrial applications – heating, lighting, robotics, traction, aerospace.

Solar PV systems – off-grid, on-grid, MPPT, wind energy systems, energy storage – lithium-ion batteries, hydrogen fuel cells, grid integration, microgrids.

Linear and switched-mode power supplies (SMPS), EV classifications – HEV, PHEV, BEV, powertrain schematic, EV charging – fast/wireless, energy storage – lithium-ion batteries, hydrogen fuel cells, future trends.

iv) (a) TEXTBOOKS

1) Ned Mohan, Tore M. Undeland, William P. Robbins, *Power Electronics: Converters, Applications, and Design*, Wiley, 3rd Edition, 2002.
2) Muhammad H. Rashid, *Power Electronics: Circuits, Devices & Applications*, Pearson, 4th Edition, 2013.
3) P.S. Bimbhra, *Power Electronics*, Khanna Publishers, 6th Edition, 2018.
4) Gopal K. Dubey, *Fundamentals of Electrical Drives*, Narosa Publishing, 2nd Edition, 2010.
5) Andrzej M. Trzynadlowski, *Introduction to Modern Power Electronics*, 3rd Edition, Wiley, 2015.
6) Iqbal Hussein, *Electric and Hybrid Vehicles: Design Fundamentals*, CRC Press, 2003.

(b) REFERENCES

1) Robert W. Erickson, Dragan Maksimovic, *Fundamentals of Power Electronics*, Springer, 2nd Edition, 2001.
2) M.D. Singh, K.B. Khanchandani, *Power Electronics*, McGraw Hill, 2nd Edition, 2007.
3) Bimal K. Bose, *Modern Power Electronics and AC Drives*, Pearson, 1st Edition, 2001.
4) R. Krishnan, *Electric Motor Drives: Modeling, Analysis, and Control*, Pearson, 1st Edition, 2001.
5) Chetan Singh Solanki, *Solar Photovoltaics: Fundamentals, Technologies, and Applications*, PHI Learning, 3rd Edition, 2021.
6) James Larminie, John Lowry, *Electric Vehicle Technology Explained*, Wiley, 2nd Edition, 2012.
7) Ali Emadi, *Advanced Electric Drive Vehicles*, CRC Press, 1st Edition, 2014.
8) D.P. Kothari, K.C. Singal, Rakesh Ranjan, *Renewable Energy Sources and Emerging Technologies*, PHI Learning, 2nd Edition, 2011.
9) Jahangir Hossain, Hemanshu Roy Pota, *Renewable Energy Integration*, Academic Press, 1st Edition, 2014.
10) Daniel M. Mitchell, *DC-DC Switching Regulator Analysis*, McGraw Hill, 1st Edition, 1988.
11) Abbasi S. A. and N. Abbasi, *Renewable Energy Sources and their Environmental Impact*, Prentice Hall of India, 2001.
12) Sawhney G. S., *Non-Conventional Energy Resources*, PHI Learning, 2012.
13) Abad, Gonzalo, *Power electronics and electric drives for traction applications*. USA: Wiley, 2017.

(c) Additional Online Learning Resources

NPTEL Courses (IITs, IISc):

- *Introduction to Power Electronics* (IIT Delhi)
- *Fundamentals of Electric Drives* (IIT Madras)
- *Energy Storage & Renewable Energy Systems* (IIT Delhi)
- *Non-conventional Energy Sources* (IIT Madras)

v) COURSE PLAN

Module	Contents	No. of hours
I	**Fundamentals of Power Processing** Introduction to power processing – Elements of power electronics – Power semiconductor devices – Uncontrolled, semicontrolled, and fully controlled switches – Diode, SCR, MOSFETs, IGBTs: Principle of operation – Advantages of wide bandgap devices: SiC, GaN – Applications of power electronics in modern systems.	9
II	**Power Conversion Circuits** AC-DC conversion: Single-phase fully controlled SCR-based bridge rectifier with R and RL load (continuous mode only) – Principle of operation and waveforms – DC-DC Converters (Non-isolated): Buck, Boost, Buck-Boost converter – Circuit operation, voltage gain, and waveforms in continuous conduction mode – DC-AC conversion: Single-phase half and full bridge inverter with R load – Square-wave operation – Types of PWM: Single pulse, multiple pulse, sinusoidal PWM – Total harmonic distortion (THD) – AC-AC conversion: Single-phase AC voltage controller with R load – Waveforms.	9
III	**Electric Drives & Industrial Applications** Electric motor drives: Introduction – Block diagram of an electric drive – 4-quadrant operation of a separately excited DC motor – Circuit diagram and waveforms – Induction motor drives: Principle of operation – v/f control – Power electronics applications in industrial systems: Heating, lighting, robotics, automation – Power electronics in aerospace and railway traction systems.	9
IV	**Power Processing in Renewable Energy Systems** Solar photovoltaic (PV) systems: Principle of operation – Off-grid and on-grid solar systems – Block diagram – Maximum power point tracking (MPPT) – Wind energy conversion systems (WECS): Working principle – Grid integration – Energy storage technologies: Lithium-ion batteries, lead-acid batteries, supercapacitors, hydrogen fuel cells – Microgrids and smart grids: Concept and applications.	9
V	**Power Processing in Power Supplies & Electric Vehicles** Power supplies: Principle of operation – Linear power supply, switched-mode power supply (SMPS) – Power supply requirements: Isolation, protection, regulation – Electric vehicles (EVs): Introduction to HEV, PHEV, BEV – Block schematic of power train – Energy storage in EVs: Li-ion batteries, hydrogen fuel cells – Charging technologies: Fast charging, wireless charging – Future trends in power electronics: AI, IoT, wide bandgap devices.	9
	Total hours	**45**

vi) ASSESSMENT PATTERN

Continuous Assessment : End Semester Examination – 40 : 60

Continuous Assessment		
Attendance	:	5 marks
Assignments	:	15 marks
Assessment through Tests	:	20 marks
Total Continuous Assessment	:	**40 marks**
End Semester Examination	:	**60 marks**
TOTAL	:	**100 marks**

vii) CONTINUOUS ASSESSMENT TEST

- No. of tests : 02
- Maximum Marks : 30
- Test Duration : 1 ½ hours
- Topics : 2 ½ modules

viii) END SEMESTER EXAMINATION

- Maximum Marks : 60
- Exam Duration : 3 hours

Course Code	Course Name	Category	L-T-P-J	Credit	Year of Introduction
23IEL31O	ELECTRICAL DRIVES AND CONTROL FOR AUTOMATION	IEC	3-0-0-0	3	2023

i) COURSE OVERVIEW

This course introduces the principles of electric drives and their role in control and automation systems. It covers the working, characteristics, and applications of DC machines, transformers, induction motors, synchronous machines, and special motors. The course also explores modern motor control techniques, including PLC-based motor control, digital controllers, and industrial automation applications. Case studies on electric drives in robotics, CNC machines, and electric vehicles provide insights into real-world applications.

ii) COURSE OUTCOMES

After the completion of the course, the student will be able to:

CO1	Explain the working principles, characteristics, and performance of DC machines, transformers, and induction motors.	Understand
CO2	Explain the construction, operation, and applications of synchronous machines, stepper motors, and servo motors.	Understand
CO3	Apply motor control strategies using digital controllers, variable frequency drives (VFDs), DSP-based controllers, and programmable logic controllers (PLCs) in industrial automation scenarios.	Apply
CO4	Explain the role of electric drives in industrial automation, robotics, and electric vehicles, supported by case studies.	Understand
CO5	Explain emerging trends in IoT-enabled motor control, AI-based predictive maintenance, and Industry 4.0 applications.	Understand

iii) SYLLABUS

DC generators – EMF equation – types of excitations – armature reaction – OCC and load characteristics – DC motors: principle, torque equation, types, characteristics, efficiency, and applications.

Transformers - Principle of operation, EMF equation, vector diagrams, losses and efficiency, OC and SC tests, equivalent circuit, auto transformers – applications.

Alternators – EMF equation – voltage regulation – synchronous motors – stepper motors – BLDC and PMSM motors – servo motors – applications in automation.

Motor control techniques – servo control – digital controllers – VFDs – DSP-based controllers – PLCs – automation case studies.

Electric drives in automation – robotics – CNC machines – electric vehicles – HVAC systems – IoT-based motor control – Industry 4.0 applications.

iv) (a) TEXTBOOKS

1) P.S. Bimbhra, *Electrical Machinery*, Khanna Publishers, 7th Edition, 2011.

2) J.B. Gupta, *Theory and Performance of Electrical Machines*, S.K. Kataria & Sons, 15th Edition, 2021.
3) Hughes & Drury, *Electric Motors and Drives: Fundamentals, Types and Applications*, Elsevier, 5th Edition, 2019.
4) B.L. Theraja & A.K. Theraja, *A Textbook of Electrical Technology - Volume II*, S. Chand, 24th Edition, 2019.
5) D.P. Kothari & I.J. Nagrath, *Electric Machines*, McGraw-Hill, 5th Edition, 2017.

(b) REFERENCES

1) V.K. Mehta & Rohit Mehta, *Principles of Electrical Machines*, S. Chand, 3rd Edition, 2018.
2) R.K. Rajput, *Electrical Machines*, Laxmi Publications, 6th Edition, 2019.
3) Kenjo & Sugawara, *Stepping Motors and Their Microprocessor Control*, Clarendon Press, 2nd Edition, 1994.
4) R. Krishnan, *Electric Motor Drives: Modeling, Analysis, and Control*, Prentice Hall, 1st Edition, 2001.
5) P.C. Sen, *Principles of Electric Machines and Power Electronics*, Wiley, 3rd Edition, 2013.
6) John W. Webb & Ronald A. Reis, *Programmable Logic Controllers: Principles and Applications*, Pearson, 5th Edition, 2014.
7) G.K. Dubey, *Fundamentals of Electrical Drives*, Narosa Publishing House, 2nd Edition, 2002.
8) Ion Boldea & Syed A. Nasar, *Electric Drives*, CRC Press, 2nd Edition, 2005.

v) COURSE PLAN

Module	Contents	No. of hours
I	**DC Machines** DC generators - Principle of operation – EMF equation – types of excitation – armature reaction – open circuit characteristics (OCC) and load characteristics – applications of DC generators. DC motors - Principle of operation – torque equation – types and characteristics – losses and efficiency – industrial applications.	9
II	**Transformers** Principle of operation – EMF equation – vector diagrams – losses and efficiency – open circuit (OC) and short circuit (SC) tests – equivalent circuit – efficiency calculations – maximum efficiency – all-day efficiency – auto transformers – industrial applications.	9
III	**Special Motors** Principle of alternators – EMF equation – voltage regulation by EMF method. Synchronous motors – principle of operation and starting methods. Stepper motors: principle of operation, types, and applications. BLDC and PMSM motors: construction, working, and applications. Servo motors and their role in automation.	9

IV	**Motor Control Techniques** Introduction to motor controllers – servo control – digital controllers – variable frequency drives (VFDs) – DSP-based motor controllers – programmable logic controllers (PLCs) in motor control – industrial automation using motor controllers – case studies in robotics and CNC machines.	**9**
V	**Electric Drives in Automation** Applications of electric drives in robotics, CNC machines, and electric vehicles – motor control in HVAC systems – IoT-enabled motor control – AI-based predictive maintenance – Industry 4.0 applications – case studies on automation and smart manufacturing.	**9**
	Total hours	**45**

vi) ASSESSMENT PATTERN

Continuous Assessment : End Semester Examination – 40 : 60

Continuous Assessment		
Attendance	:	5 marks
Assignments	:	15 marks
Assessment through Tests	:	20 marks
Total Continuous Assessment	:	**40 marks**
End Semester Examination	:	**60 marks**
TOTAL	:	**100 marks**

vii) CONTINUOUS ASSESSMENT TEST

- No. of tests : 02
- Maximum Marks : 30
- Test Duration : 1 ½ hours
- Topics : 2 ½ modules

viii) END SEMESTER EXAMINATION

- Maximum Marks : 60
- Exam Duration : 3 hours

Course Code	Course Name	Category	L-T-P-J	Credit	Year of Introduction
23IEL31P	ARTIFICIAL INTELLIGENCE IN POWER SYSTEMS	IEC	3-0-0-0	3	2023

i) COURSE OVERVIEW

This course explores the application of AI in power systems, covering machine learning, deep learning, and data analytics for renewable energy forecasting, smart grids, predictive maintenance, and system optimization. It also addresses ethical and cybersecurity challenges in AI-driven power systems.

ii) COURSE OUTCOMES

After the completion of the course, the student will be able to:

CO1	Explain the fundamentals of power systems and AI techniques applicable to them.	Understand
CO2	Explain AI-based forecasting, optimization, and control strategies in power systems.	Understand
CO3	Explain predictive maintenance, fault detection, and real-time monitoring using AI.	Understand
CO4	Explain AI-based techniques for load forecasting, predictive maintenance, grid stability, optimization, and control in power system operations.	Understand
CO5	Apply AI methods to develop solutions for real-time monitoring, fault detection, optimal power dispatch, and adaptive control in power systems.	Apply

iii) SYLLABUS

Power generation, transmission, and distribution overview, AI and machine learning basics, supervised, unsupervised, and reinforcement learning, common AI algorithms.

Data acquisition, preprocessing, and feature extraction, AI/ML applications (regression, classification, clustering, time-series analysis), overview of Python libraries and simulation tools.

AI-driven forecasting for solar and wind energy, smart grids, IoT integration, energy storage optimization, demand response strategies.

Load forecasting, predictive maintenance, fault detection, real-time grid monitoring, AI for grid stability and contingency analysis.

AI-based optimization in power dispatch and unit commitment, AI-driven voltage and frequency regulation, adaptive control, ethical considerations, cybersecurity in AI applications.

iv) (a) TEXTBOOKS

1) S.A. Soman, S.A. Khaparde, and Shubha Pandit, *Artificial Intelligence in Power System Analysis*, CRC Press, 2020.

2) James Momoh, *Smart Grid: Fundamentals of Design and Analysis*, Wiley-IEEE Press, 2012.
3) Amit Kumar, Om Pal, and Arun Kumar Singh, *Artificial Intelligence and Machine Learning in Power System Operations*, Springer, 2023.
4) Jan Machowski, Janusz W. Bialek, and James R. Bumby, *Power System Dynamics: Stability and Control*, Wiley, 2020.

(b) REFERENCES

1) Mohammad Shahidehpour and Muwaffaq Alomoush, *Restructured Electric Power Systems: Analysis of Electricity Markets with Equilibrium Models*, Wiley-IEEE Press, 2001.
2) Bin Lu and M. Shahidehpour, *Short-Term Load Forecasting Using Stochastic Learning Networks*, IEEE Transactions on Power Systems, 2005.
3) Trevor Hastie, Robert Tibshirani, and Jerome Friedman, *The Elements of Statistical Learning: Data Mining, Inference, and Prediction*, Springer, 2017.
4) Francisco D. Bianchi, Hernán De Battista, and Ricardo J. Mantz, *Wind Turbine Control Systems: Principles, Modelling and Gain Scheduling Design*, Springer, 2006.
5) Research papers and IEEE Transactions on Power Systems and Smart Grids.

v) COURSE PLAN

Module	Contents	No. of hours
I	**Fundamentals of Power Systems & Introduction to AI** Fundamentals of Power Systems - Overview of Power Generation, Transmission, and Distribution, Overview of conventional and renewable power plants. Introduction to AI and Machine Learning - History and evolution of AI, Core concepts in machine learning: supervised, unsupervised, and reinforcement learning, Overview of common algorithms.	9
II	**AI Techniques and Tools for Power Systems Applications** Data Acquisition and Preprocessing: Data sources in power systems (SCADA, PMU, smart meters), Data cleaning and feature extraction techniques. AI/ML Algorithms for Energy Applications: Regression, classification, clustering, and time-series analysis, Introduction to deep learning and neural networks tailored for forecasting and classification tasks. Software Tools & Platforms: Overview of Python libraries (TensorFlow, PyTorch, Scikit-learn), Simulation and modeling platforms for power systems.	9
III	**AI in Renewable Energy Integration & Smart Grids** Solar and wind energy generation forecasting using AI, Handling variability and uncertainty in renewable outputs. Smart Grid Technologies: Role of AI in optimizing smart grid operations, Integration of IoT, advanced metering infrastructure (AMI), and 5G communications.	9

	Energy Storage and Demand Response: AI-driven energy storage management strategies, Demand response programs and optimization of energy distribution.	
IV	**AI Applications in Power System Operations** Load Forecasting and Demand Prediction: Short-term and long-term forecasting models, Case examples using time-series forecasting techniques. Predictive Maintenance and Fault Detection: Condition monitoring and anomaly detection in critical infrastructure, AI-driven approaches to predictive maintenance of equipment. Grid Stability and Real-Time Monitoring: Techniques for real-time data analytics and fault diagnosis, AI methods for managing dynamic stability and contingency analysis.	**9**
V	**Optimization, Control, and Future Directions** Optimization in Power Systems: Techniques for optimal power flow (OPF) and unit commitment using AI, Energy dispatch optimization and cost minimization strategies. Advanced Control Systems: AI-driven control for voltage and frequency regulation, Fault-tolerant and adaptive control systems in real-time operations. Ethical, Security, and Future Trends: Ethical considerations and cybersecurity challenges in AI applications.	**9**
	Total hours	**45**

vi) ASSESSMENT PATTERN

Continuous Assessment : End Semester Examination – 40 : 60

Continuous Assessment		
Attendance	:	5 marks
Assignments	:	15 marks
Assessment through Tests	:	20 marks
Total Continuous Assessment	:	**40 marks**
End Semester Examination	:	**60 marks**
TOTAL	:	**100 marks**

vii) CONTINUOUS ASSESSMENT TEST

- No. of tests : 02
- Maximum Marks : 30
- Test Duration : 1 ½ hours
- Topics : 2 ½ modules

viii) END SEMESTER EXAMINATION

- Maximum Marks : 60
- Exam Duration : 3 hours

INSTITUTE ELECTIVE II

Course Code	Course Name	Category	L	T	P	J	Credit	Year of Introduction
23IEL42M	ARCHITECTURAL LIGHTING DESIGN AND CONTROL	IEC	2	1	0	0	3	2023

i) **COURSE OVERVIEW**: This course explores the principles of architectural lighting design and control, covering fundamental lighting concepts, lamp technologies, and luminaire types. It includes interior, exterior, and specialized lighting designs, emphasizing energy efficiency, daylight integration, and automation using smart control systems. Students will gain insights into modern lighting techniques, sustainable solutions, and real-world applications in buildings, streets, and urban environments.

ii) **COURSE OUTCOMES**

After the completion of the course, the student will be able to:

CO1	Explain the fundamental principles of light, illumination, and various lamp technologies used in architectural lighting.	Understand
CO2	Illustrate the various types of luminaires and their structural features	Understand
CO3	Develop the lighting scheme for efficient indoor lighting system	Apply
CO4	Develop the lighting scheme for efficient outdoor and specialized lighting system	Apply
CO6	Demonstrate smart and sustainable lighting practices and lighting controls for modern architecture.	Understand

iii) **SYLLABUS**

Role of lighting in architecture, Fundamentals of Lighting and Lamps –Quality of lighting-lamp types- Fluorescent, LED, Sodium vapour, Mercury vapour lamps

Luminous flux, Luminous intensity, Lumen, Candle power, Illumination - Luminaire types – Reflectors, refractors, mounting types, Fixture selection.

Interior Lighting Design – Illumination calculations, Average lumen method, Space-to-mounting height ratio, Lighting design for seminar halls, offices, residences, Staircase, corridor, and entrance lighting, Human-centric lighting.

Outdoor and Specialized Lighting – Road and street lighting, Spacing-to-mounting height ratio, Flood lighting, Façade lighting, Landscape and garden lighting, S

Smart Lighting Systems – Lighting control methods, Dimmers, Motion and occupancy sensors, Photo sensors, Timers, IoT-based lighting, Smart city lighting automation.

DALI, DMX, Sustainable lighting strategies.

iv) **(a) TEXT BOOKS**

1) G. Steffy, *Architectural Lighting Design*, John Wiley & Sons, 2nd Edition, 2013.

2) M. David Egan and Victor Olgyay, *Architectural Lighting*, McGraw-Hill Education, 3rd Edition, 2002.
3) Claude Engle, *Lighting: Basics, Concepts and Applications*, Fairmont Press, 1st Edition, 2010
4) Craig DiLouie, *Advanced Lighting Controls: Energy Savings, Productivity, Technology and Applications*, Fairmont Press, 1st Edition, 2006.
5) Robert Simpson, *Lighting Control: Technology and Applications*, Taylor and Francis, 2003.
6) M K Giridharan, *Electrical System Design*, I K International Publishing House Pvt. Ltd, 2015.
7) M.S. Rea, *The IESNA Lighting Handbook*, Illuminating Engineering Society of North America (IESNA), 10th Edition, 2011.
8) R. G. Hopkinson, *Lighting for Architecture*, Elsevier, 2013.

(b) REFERENCES

1) D.C. Pritchard, *Lighting*, 6th edition, Routledge, 2014
2) Jack L. Lindsey, *Applied Illumination Engineering*, The Fairmont Press Inc.
3) M.A. Cayless, *Lamps and Lighting*, Routledge, 1996.
4) Mohamed Boubekri, *Daylighting, Architecture and Health: Building Design Strategies* Architectural Press, UK.
5) Mark Karlen, James Benya, *Lighting Design Basics*, Wiley, 3rd Edition, 2017.
6) Peter Tregenza, David Loe, *The Design of Lighting*, Routledge, 2013.
7) Gary Gordon, *Interior Lighting for Designers*, Wiley, 5th Edition, 2015.

v) COURSE PLAN

Module	Contents	No. of hours
I	**Introduction to Lighting in Architecture:** Role of lighting in architecture – visual comfort, aesthetics, safety, productivity. Quality of Lighting: Brightness balance, uniformity, shadow and modelling. Color rendering index (CRI), Glare - Lighting systems- direct, indirect, semi direct, semi indirect, Types of lamps – Fluorescent, LED, High & Low-pressure sodium vapour lamps, Metal halide - Solid state lighting – LEDs and OLEDs- Comparative analysis of lamp technologies – Energy efficiency, lifespan, color rendering	9
II	Definition of luminous flux, Luminous intensity, Lumen, Candle power, Illumination, Lamp efficiency, Illuminance, Laws of illumination, Inverse square law and Lambert's Cosine law. **Types of luminaires:** recessed, surface-mounted, pendant, track, wall-mounted- Fixture selection based on applications - Luminaire selection criteria **Optical systems –** reflectors, lenses, diffusers. Ingress protection (IP) ratings. Thermal management in luminaires.	8

III	**Interior Lighting Design:** Maintenance factor, Uniformity ratio, Direct ratio, Coefficients of utilization-LLF- factors affecting-Illumination calculations – Average lumen method, Space to mounting height ratio, Design of Seminar halls, offices, residential spaces – Lighting for staircases, corridors, and entrances – Auditorium lighting.	**10**
IV	**Outdoor and Specialized Lighting:** Road lighting design – Spacing to mounting height ratio, Street lighting arrangements – Pole placements and fixture types Flood lighting design – Selection of lamps and projectors. Façade lighting techniques – floodlighting, grazing, wall washing, Landscape and garden lighting.	**9**
V	**Lighting Controls and Smart Systems:** Need for Lighting Controls-Types: switches, dimmers, Automatic controls – occupancy sensors, daylight sensors, timers. DALI, DMX protocols -Wireless lighting controls. **Smart Lighting Systems:** Human Centric Lighting (HCL) – Introduction to IoT-based lighting -Case studies on energy-efficient lighting in urban environments **Sustainable lighting:** Daylight harvesting- lighting in green buildings	**9**
	Total hours	**45**

vi) CONTINUOUS ASSESSMENT EVALUATION PATTERN

Attendance	:	5 marks
CA Exams (2 numbers)	:	20 marks
Assignment/Project/Case study etc.	:	15 marks
Total	:	**40 marks**

vii) CONTINUOUS ASSESSMENT EXAMINATION PATTERN

- Two tests of 30 marks each (2 ½ modules to be covered in each exam)
- Duration – 1.5 hours

viii) END SEMESTER EXAMINATION PATTERN

- Two parts - Part A and Part B – with a total of **60 marks**
- Part A contains compulsory questions. Part B contains choice questions.
- Duration – 3 hours

Course Code	Course Name	Category	L	T	P	J	Credit	Year of Introduction
23IEL42N	ELECTRIC VEHICLES	IEC	3	0	0	0	3	2023

i) COURSE OVERVIEW:

The main goal of this course is to expose the students to the fundamental concepts and trends in electric and hybrid vehicles. It gives an insight into the drive system, battery management system and energy sources used in electric vehicles.

ii) COURSE OUTCOMES

After the completion of the course, the student will be able to:

CO1	Apply hybrid electric vehicle architecture principles to determine the overall vehicle performance metrics.	Apply
CO2	Illustrate the fundamental principles and provide a comparative study of diverse Electric Vehicle and Hybrid Electric Vehicle powertrain architectures.	Understand
CO3	Outline the architecture and operational characteristics of propulsion systems utilized in electric and hybrid-electric transport.	Understand
CO4	Explain mathematical battery modelling techniques, examine various battery chemistries and illustrate their respective charging methods.	Understand
CO5	Summarize various communication protocols and technologies used in vehicle networks and high efficiency battery charging infrastructures for automotive applications.	Understand

iii) SYLLABUS

Conventional Vehicles, Basics of vehicle performance, Basic Architecture of hybrid traction, Electric Drive Drain, Power flow control.
Electric Propulsion unit: Configuration and control of DC motor drives and Induction Motor drives.
Energy Storage Requirements in Hybrid and Electric Vehicles, Battery modelling.
Communication Systems, Overview of EV battery chargers, Energy Management Strategies.

iv) (a) TEXT BOOKS

1) Iqbal Husain: *Electric and Hybrid vehicles: Design Fundamentals,* CRC press, 3rd Edition 2021.
2) Ehsani M., *Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design*, CRC Press, 2005.
3) Gianfranco Pistoia, *Electric and Hybrid Vehicles: Power Sources, Models, Sustainability, Infrastructure and the Market,* Elsevier,2010.

4) Chan C. C. and Chau K. T., *Modern Electric Vehicle Technology,* OXFORD University Press, 2001.

(b) REFERENCES

1) James Larminie, John Lowry, *Electric Vehicle Technology Explained*, 2nd Edition Wiley 2003.
2) Fuhs A. E., *Hybrid Vehicles and the Future of Personal Transportation,* CRC Press, 2009.
3) Chris Mi , Abul Masrur M., *Hybrid Electric Vehicles: Principles and Applications with Practical Perspectives,* 2nd Edition, John Wiley & Sons Ltd, 2017.
4) Sheldon S. Williamson, *Energy Management Strategies for Electric and Plug-in Hybrid Electric Vehicles*, Springer, 2013.
5) Dishore S.V, Electric Vehicle Architecture, Lakshmi Publications,2023.

(c) ONLINE RESOURCES

1) NPTEL courses/Materials (IITG, IITM,IITD) – Electric and Hybrid vehicles
https://nptel.ac.in/courses/108/103/108103009/ (IIT Guwahati)
https://nptel.ac.in/courses/108/102/108102121/ (IIT Delhi)
https://nptel.ac.in/courses/108/106/108106170/ (IIT Madras)
2) FOC Control - video lecture by Texas Instruments
https://training.ti.com/kr/field-oriented-control-permanent-magnet-motors
3) Sensored and sensorless FOC control of PMSM motors – Application notes (TI, MATLAB)
https://www.ti.com/lit/an/sprabz0/sprabz0.pdf?ts=1620018267996&ref_url=https%253A%252F%252Fwww.google.com%252F
https://in.mathworks.com/help/physmod/sps/ref/pmsmfieldorientedcontrol.html
4) Electric Vehicle Conductive AC Charging System
https://dhi.nic.in/writereaddata/UploadFile/REPORT%20OF%20COMMITTEE636469551875975520.pdf
Electric Vehicle Conductive AC Charging System

v) COURSE PLAN

Module	Contents	No. of hours
I	**Introduction to Hybrid Electric Vehicles**: History of hybrid and electric vehicles, social and environmental importance of hybrid and electric vehicles. **Basics of vehicle performance**, vehicle power source characterization, transmission characteristics, mathematical models to describe vehicle performance. **Autonomous Vehicles:** Levels of automation, significance & effects of automation in vehicles.	9
II	**Hybrid Electric Drive-trains**: Basic concept of hybrid traction, introduction to various hybrid drive-train topologies, power flow control in hybrid drive-train topologies.	8

	Electric Drive-trains: Basic concept of electric traction, introduction to various electric drive-train topologies, power flow control in electric drive-train topologies. Comparative insights into BEV, HEV, PHEV and Fuel Cell EV architectures.	
III	**Electric Propulsion unit:** Introduction to electric components used in hybrid and electric vehicles. Four quadrant operation. Configuration and control of separately excited DC motors, Induction Motors (block diagram representation of FOC), voltage and frequency control.	**8**
IV	**Battery Modeling, Types and Charging**: Batteries in Electric and Hybrid Vehicles-Battery Basics -Battery Parameters. Battery Modelling, Electric Circuit Models. Types-Lead Acid Battery-Nickel-Cadmium Battery-Nickel-Metal-Hydride (NiMH) Battery-Li-Ion Battery -Li-Polymer Battery, Sodium-Sulphur Battery, Sodium-Metal-Chloride, Battery Charging methods.	**10**
V	**Communications**, supporting subsystems: In vehicle networks-Communication Protocols - CAN, LIN, FLEXRAY (Basics only). **Overview of Electric Vehicle Battery Chargers** - On-board chargers, Electric Vehicle Supply Equipment (EVSE) - Grid to vehicle power flow block schematic diagrams. Types of charging stations - AC Level 1 & 2, DC - Level 3. **Introduction to energy management strategies**: Classification of different energy management strategies, comparison of different energy management strategies.	**10**
	Total hours	**45**

vi) CONTINUOUS ASSESSMENT EVALUATION PATTERN

Attendance	:	5 marks
CA Exams (2 numbers)	:	20 marks
Assignment/Project/Case study etc.	:	15 marks
Total	:	**40 marks**

vii) CONTINUOUS ASSESSMENT EXAMINATION PATTERN

- Two tests of **30 marks each** (2 ½ modules to be covered in each exam)
- Duration – 1.5 hours

viii) END SEMESTER EXAMINATION PATTERN

- Two parts - Part A and Part B – with a total of **60 marks**
- Part A contains compulsory questions. Part B contains choice questions.
- Duration – **3 hours**

Course Code	Course Name	Category	L	T	P	J	Credit	Year of Introduction
23IEL42O	Process Control and Automation	IEC	3	0	0	0	3	2023

i) **COURSE OVERVIEW**: The course aims to familiarize students with the concepts of process control. It presents basic control system concepts to enable students to model and analyse physical systems in time domain. Students will be introduced to classical controllers and advanced control strategies used in process control. The different components like actuators, control valves, PLCs and industrial robots used for process automation will also be introduced.

ii) **COURSE OUTCOMES**

After the completion of the course, the student will be able to:

CO1	Explain the basic concepts of control systems.	Understand
CO2	Apply time domain techniques for response analysis of physical systems.	Apply
CO3	Explain the concepts of system stability, types of classical controllers and advanced control strategies in process control.	Understand
CO4	Explain the architecture of Industrial Automation Systems and its components.	Understand
CO5	Build simple ladder programs for operation of PLC.	Apply
CO6	Explain the use of industrial robots.	Understand

iii) **SYLLABUS**

Basic concepts of control systems - Process control block diagram – Control system evaluation – Transfer function - Modelling of physical systems – Response analysis of first order and second order systems - Linearisation - Time domain and frequency domain specifications – Transportation lag – Concept of stability – On-off, P, PI and PID Controllers – Ziegler Nichol's tuning method - Advanced control strategies – Process Identification -Automation architecture - Actuators - Control Valves- Discrete state process control - Programmable Logic Controllers - Ladder programming – Industrial robots – Robot subsystems, classification and Applications.

iv) (a) **TEXT BOOKS**

1) Coughanowr, D. R., LeBlanc S., *Process Systems Analysis and Control*, 3rd edition, McGraw-Hill, 2008.
2) C. D. Johnson, *Process control Instrumentation Technology*, Pearson Education, Eighth Edition, 2006, PHI, 8th Edition, 2013.
3) William L. Luyben, *Process Modelling, Simulation and Control for Chemical Engineers*, Mc- Graw Hill, 2nd edition, 1996.

4) Surekha Bhanot, *Process Control - Principles & Applications*, Oxford University Press, 2008.
5) S. K. Saha, *Introduction to Robotics*, McGraw Hill Education Pvt. Ltd., 2nd edition, 2014.
6) Norman S. Nice, *Control Systems Engineering*, 6th edition, 2011.

(b) REFERENCES

1) Stephanopoulos G., *Chemical Process Control: An Introduction to Theory and Practice*, Pearson Education (1984), PHI, 2006.
2) B. Wayne Bequette, *Process control: Modeling, Design and simulation*, Prentice Hall of India (P) Ltd., 2003.
3) Huges T, *Programmable Controllers*, ISA press, 4th Edition Illustrated, 2005.
4) Considine D.M., *Process Instruments and Controls Handbook*, Second Edition, McGraw, 1999.
5) G. Liptak, *Handbook of Process Control*, 1996.
6) K. Krishnaswamy, *Process Control*, New Age International, 2007.
7) Patranabis D., *Principles of Process Control*, Tata McGraw Hill, New Delhi, 3rd edition, 2017.

v) COURSE PLAN

Module	Contents	No. of hours
I	**Introduction to Process Control Systems:** Process Control principles – self regulated system, Human aided control, Automatic control, Servomechanisms, Discrete state control systems, Open loop and closed loop systems, Process Control block diagram, Control System evaluation – objective, stability, steady state and transient regulations, Evaluation criteria. Concept of transfer function, Poles and zeros, Type and order, Standard test signals.	9
II	**Linear System Analysis:** Time domain specifications – Delay time, Rise time, Peak time, Peak Overshoot, Settling time. Linear open loop systems: Response of first order systems: Step response, impulse response. Physical examples of first order systems: Modelling of liquid level control, mixing process and heating process as first order systems, Concept of linearization of system model. Response of first order systems in series – Non-interacting and interacting systems for liquid level control. Response analysis of second order systems – Undamped, underdamped, critically damped and overdamped systems. Frequency response – Frequency domain specifications – Resonant Peak, Resonant Frequency, Bandwidth, Gain margin and Phase margin. Modelling of transportation lag.	9
III	**Closed-Loop Control Systems & PID Controllers:** Linear Closed loop systems: Closed loop system - Characteristic equation, Concept of stability, Location of poles and stability, Routh's stability test. Study of	9

	ON-OFF control, P, PI and PID controllers, Ziegler Nichol's method for PID tuning. Advanced Control strategies: Cascade control, Feedforward control, Ratio Control, Smith Predictor control, Selective control, Model Reference Adaptive Control.	
IV	**Industrial Automation & Actuators:** Process Identification and automation: Direct methods – Time domain eyeball fitting of Step test data, Direct sine wave testing. Architecture of Industrial Automation Systems: Final control operation – Actuators and Control elements. Actuators – Construction, Principle, Advantages and disadvantages of Hydraulic, Pneumatic and Electrical actuators. Control elements – Control Valves construction and principle, Types –quick opening, linear, equal percentage, Classification	**9**
V	**Discrete State Control & Robotics:** Programmable Logic Controllers – architecture and operation, Comparison of PLC & PC, Relays and Ladder Logic, Ladder Programming – Basic symbols used, Realization of AND, OR logic, Concept of latching. Introduction to Timer/Counters- Simple ladder programs Industrial Robots: Robot Subsystems – Motion, Recognition and Control subsystems, Classification of Robots – Based on work envelope, actuation and motion control methods, Industrial Applications – Material handling, welding, spray painting, machining, assembling.	**9**
	Total hours	**45**

vi) CONTINUOUS ASSESSMENT EVALUATION PATTERN

Attendance	:	5 marks
CA Exams (2 numbers)	:	20 marks
Assignment/Project/Case study etc.	:	15 marks
Total	:	**40 marks**

vii) CONTINUOUS ASSESSMENT EXAMINATION PATTERN

- Two tests of **30 marks each** (2 ½ modules to be covered in each exam)
- Duration – 1.5 hours

viii) END SEMESTER EXAMINATION PATTERN

- Two parts - Part A and Part B – with a total of **60 marks**
- Part A contains compulsory questions. Part B contains choice questions.
- Duration – **3 hours**

Course Code	Course Name	Category	L	T	P	J	Credit	Year of Introduction
23IEL42P	SUSTAINABLE ENERGY MANAGEMENT	IEC	3	0	0	0	3	2023

i) COURSE OVERVIEW:

The main goal of this course is to enable the students to understand the concept of sustainable energy management. The course helps the students to understand the different methods used for energy management and economic analysis of energy.

ii) COURSE OUTCOMES

After the completion of the course, the student will be able to:

CO1	Explain the significance of energy management and planning.	Understand
CO2	Summarize energy management opportunities in electric lighting, transformers and motor loads.	Understand
CO3	Identify energy management strategies in industries and commercial establishments.	Apply
CO4	Explain Demand Side Management techniques.	Understand
CO5	Make use of various methods for economic energy analysis.	Apply

iii) SYLLABUS

Energy Management - General Principles and Planning. Energy management opportunities in Lighting, Transformers and Motors.

Energy management in industries and commercial establishments-Energy conservation in boiler and steam. Heat recovery systems- cogeneration.

Demand Side Management- techniques of DSM. Load management, load priority technique, peak clipping, peak shifting, valley filling, strategic conservation, energy efficient equipment.

Energy Economics: Economic analysis: methods. Computer aided Energy Management Systems.

iv) (a) TEXT BOOKS

1) Mirjana Radovanović, Sustainable Energy Management: Planning, Implementation, Control and Strategy, 2nd edition, Academic Press (Elsevier), 2022.
2) Akilu Yunusa-Kaltungo (Ed.), Key Themes in Energy Management, Springer Nature, 2024.
3) Vinay Kandpal, Rakesh Kumar, Ashok Kumar (Eds.), Sustainable Energy Transition: Circular Economy and ESG Practices, Springer, 2024.

4) Craig B. Smith, Kelly E Parmenter, Energy management principles: Applications, Benefits, Savings, 2nd edition, Pergamon Press, 2001.
5) Charles M. Gottschalk, Industrial energy conservation, John Wiley & Sons, 1996.
6) D. Yogi Goswami, Frank Kreith, Energy Management and Conservation Handbook,2nd edition, CRC Press, 2016.
7) G.G. Rajan, optimizing energy efficiencies in industry, Illustrated edition, Tata McGraw Hill, Pub. Co., 2001.

(b) REFERENCES

1) IEEE recommended practice for energy management in industrial and facilities.
2) IEEE std 739 - 1995 (Bronze book).
3) M Jayaraju and Premlet, Introduction to Energy Conservation and Management, 3rd edition, Phasor Books, 2008.
4) Paul O'Callaghan, Energy management, 1st edition, McGraw Hill Book Co., 1993.
5) Wayne C. Turner, Steve Doty, Stephen A. Roosa, ***Energy Management Handbook***, 10th edition, **River Publishers,** 2025..

v) COURSE PLAN

Module	Contents	No. of hours
I	Review of Sustainable Development Goals. **Energy Management**: General principles of Energy management and Energy management planning. Peak demand control-methodologies. **Energy Efficiency in Lighting**: Modern energy efficient light sources, life and efficacy comparison with older light sources, energy conservation in lighting, use of sensors and lighting automation.	9
II	**Energy Efficiency in Motors:** Development of energy efficient motors and the present status, techniques for improving energy efficiency, necessity for load matching. **Energy efficiency in Transformers:** Present maximum efficiency standards for power and distribution transformers, design measures for increasing efficiency in electrical system components.	9
III	**Energy Management in Industries and Commercial Establishments**: Boiler - working principle - blow down, energy conservation opportunities in boilers. Identifying opportunities for energy savings in steam distribution. General fuel economy measures, energy conservation opportunities in furnaces - Case study. **Heat Recovery Systems**: Waste heat recovery system - Energy saving opportunities. Cogeneration-Types and Schemes, Optimal operation of cogeneration plants - Case study. Assessment of carbon foot-print, life cycle analysis (LCA), sustainable building codes and basics of energy auditing.	11
IV	**Demand Side Management (DSM):** Introduction to DSM, benefits of DSM, Different techniques of DSM - time of day pricing, multi-utility power exchange model, time of day models for planning. Load management, load priority technique, strategic conservation, energy	9

	efficient equipment.	
V	**Energy Economics**: Economic analysis methods, cash flow model, time value of money, pay-back period, average rate of return method, present value method, life cycle costing approach. Digital Energy Management Systems (EMS) – Basic Concepts.	**7**
	Total hours	**45**

vi) CONTINUOUS ASSESSMENT EVALUATION PATTERN

Attendance	:	5 marks
CA Exams (2 numbers)	:	20 marks
Assignment/Project/Case study etc.	:	15 marks
Total	:	**40 marks**

vii) CONTINUOUS ASSESSMENT EXAMINATION PATTERN

- Two tests of **30 marks each** (2 ½ modules to be covered in each exam)
- Duration – 1.5 hours

viii) END SEMESTER EXAMINATION PATTERN

- Two parts - Part A and Part B – with a total of **60 marks**
- Part A contains compulsory questions. Part B contains choice questions.
- Duration – **3 hours**